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CANADIAN PACIFIC RAILWAY COMPANY

IRRIGATION DEPARTMENT.

General Instructions

TO

Engineering Staff.

CALGARY, ALBERTA,

15TH APRIL, 1908.

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Canadian Pacific Railway Co.

IRRIGATION DEPARTMENT.

General Instructions to Engineering Staff

I. ORGANIZATION.

(A) Discipline.

Division
Engineers

(1) Division Engineers will report to and receive instructions from the Assistant Chief Engineer on all matters of routine, administration of discipline, land areas, accounts, payrolls, estimates, and progress of construction. They will report to, and receive instructions from the Chief Division Engineer on all matters connected with location and standards of construction, and all details thereof.

Division Engineers will be in full direct charge of all matters of every kind, other than operation, in the districts under their charge and supervision. They will be expected to keep in close touch with their assistants, and should visit each party **IN THE FIELD** at least once in each week. They are responsible for the discipline of all parties under them; and have, and are expected to exercise, full power to deal with any breaches thereof. When it is necessary to discharge any person, or in case of resignation, they must send to Strathmore a statement of the time worked by such person since the last payroll, on forms provided for such purpose, and a statement of the reason of such discharge or resignation. They will see to it that these, or any special instructions are rigidly adhered to by all parties under their authority, and they will be held responsible that all surveys, locations or constructions are carried out on standard lines, and that standard plans and specifica-

tions are followed by all concerned. They are responsible for all Company stores, equipment, material and supplies, and will deal promptly and directly with any wilful or unnecessary waste or abuse of the same.

**Operating
Engineers**

(2) Operating Engineers will report to, and receive instructions from the Asst. Chief Engineer. They will have charge of the operating force, and all work connected with the maintenance and repairs necessary in connection with portions of the system which may be turned over to them when completed. They will also transact such special duties as may be assigned them by the Asst. Chief Engineer from time to time.

**Assistant
Engineers**

(3) Assistant Engineers will report to, and receive instructions from the Division Engineer under whom they are working, unless instructed to report direct to headquarters. They will make such surveys and do such instrumental and office work as may be ordered by him, and all such work as is necessary for the proper conduct of location or construction, and the surveys preliminary or necessary thereto, whether such work is ordered by him or not, and will oversee construction when it is in progress in their districts. They are responsible to the Division Engineer for the proper discipline of their parties, and must immediately report to him any proposed discharge or resignation, with the reasons therefor. Such discharges however, must be confirmed by the Division Engineer before becoming effective. Assistant Engineers are responsible to the Division Engineer for the proper care and use of all company stores, equipment, material, or supplies in their charge, and must report any wilful or unnecessary waste or abuse of the same by any person.

In case of dispute with any contractor or foreman they will report the circumstances to the Division Engineer for his action, and will not under any conditions make any promises to, or have any communications with any contractor or foreman regarding matters in dispute. This does not preclude Assistant Engineers from notifying contractors of work not in accordance with the specifications; but when any such notification is sent, it must be in writing, and a copy of such notification must be forwarded to the Division Engineer. Assistant Engineers are re-

sponsible to the Division Engineer that all construction is according to specifications and plans, and that no variation therefrom is permitted without written instructions to that effect. They will issue, in writing, when authorized to do so, authority for extra work by contractors, and will be responsible that such work is properly and economically performed. Assistant Engineers will make monthly estimates as provided in the specifications and contract, and will be held responsible that all work done is classified and measured in accordance therewith. They will keep their records up-to-date and must do such evening work as may be necessary to that end. Records will be kept in standard form as herein-after outlined.

Chief
Inspector

(4) The Chief Inspector will report to and receive instructions from the Chief Division Engineer. He will be responsible for the quality of all timber or concrete construction, and must see that all standard plans are followed, with such modifications as may be authorized. He will also transact such other duties as may be assigned to him from time to time by the Assistant Chief Engineer.

Inspectors

(5) Assistant Engineers and Inspectors in charge of timber or concrete construction will report to and receive instructions from the Chief Inspector on all questions having reference to the quality of construction and the carrying out or modification of standard plans. On all other matters they will report to and receive instructions from the Division Engineer, whom they must help in the preparation of maps, plans or records when required to do so, and they must be prepared to do whatever night work is necessary when so instructed.

Rodmen

(6) Rodmen must faithfully carry out the duties in the field assigned them by the Engineer under whom they are working, and must also help Engineers in the preparation of any maps, plans or records, when required to do so, and be prepared to do whatever night work is necessary when so instructed.

Chainmen

(7) Chainmen must faithfully carry out the duties in the field assigned them by the Engineer under whom they are working. They will be held responsible that a sufficient supply of stakes

is always ready for use, and must notify the Engineer when additional material is required. They are responsible for any axes, chains or tapes in their charge, and in event of loss or breakage without reasonable excuse, will be charged with the cost of repairs or renewal.

Teamsters (8) Teamsters are responsible for the proper care and treatment of all horses and transport entrusted to their care. They must be prepared to help chainmen when called upon to do so, and must do any other work which may be assigned them by the Engineer.

All Employees (9) All persons employed by this Department will act in accordance with instructions issued from time to time by proper authority.

(B) Returns and Reports.

Weekly Returns
Force Account (10) Engineers are required to return, each week, an account of the force employed and plant in use on the various sections in their divisions. Forms will be supplied for this purpose, and shall be made up by Assistant Engineers, each Monday, for the week before. They shall be initialled by the Division Engineer, and forwarded to the Asst. Chief Engineer on first convenient opportunity.

Monthly Returns (11) The following monthly returns are required from Engineers:

Payrolls (a) Payrolls will be made up monthly by the Division Engineer, on forms supplied, covering all the men working under him. They shall reach the Asst. Chief Engineer not later than the 28th of each month.

Requisition for Supplies (b) Each Engineer in charge of a camp will make a requisition on the Stores Department at Strathmore, once a month, for the supplies estimated as being necessary for the next thirty days. When convenient, he will procure these with his own transport. Fresh meat will be supplied once each week.

A statement of the expenditure of each camp will be made out by the Storekeeper each month, and a copy thereof forwarded to the Engineer in charge, and all Engineers must guard against waste or unnecessary expense.

Accounts
Contracted

(c) Assistant or Division Engineers incurring necessary indebtedness on account of the Company, must procure bills in triplicate covering the sums promptly at the end of each month. These must be certified to by the Division Engineer, and forwarded to the Asst. Chief Engineer, and should state the work against which each should be charged.

Engineers must not procure supplies or camp equipment from local dealers, except in emergency or at their own expense, unless with authority from the Asst. Chief Engineer or Storekeeper.

Estimates of
work per-
formed by
Contractors

(d) At the close of each month, each Asst. Engineer will make up, in duplicate, an estimate of the work performed to date by the contractors, and return same to the Division Engineer, who, after checking them carefully will send same to the Asst. Chief Engineer at Strathmore, in whose hands they must be not later than the 28th of each month. Forms will be supplied for this purpose.

No information will be given to contractors or sub-contractors in reference to their estimates, by any members of the staff.

General
Progress
Reports

Division Engineers will send to Headquarters at Strathmore a monthly report, giving a concise statement of surveys made, work done, and constructions under way and accomplished, with a general report on the Division as a whole. The report should state: the mileage completed with and without structures, mileage opened but not completed, mileage on which nothing has been done, and an estimate of the time required to complete with the available force.

Statement
of parcels
supplied
with Gates

(e) A statement is to be made monthly to the Asst. Chief Engineer showing all parcels of land for which gates have been built in each District and which are ready to deliver water when required.

Statement of
Parcels sup-
plied with
Measuring
Weirs

(f) A similar statement to the above is to be made monthly to the Asst. Chief Engineer regarding gates supplied with measuring weirs.

Periodical
Returns

12. The following periodical returns are required from Engineers :

Inventory
of Equip-
ment and
Supplies

(a) Within thirty days of the commencement of the work, each Asst. Engineer will make a complete inventory of all property of the Company in his hands. This will be delivered to and initialled by the Division Engineer, and forwarded by him to the Asst. Chief Engineer. Forms will be supplied for this purpose. This must also be done at the close of the season's operations.

Statements
of Irrigable
and Non-
Irrigable
Areas

(b) A statement of Irrigable and Non-Irrigable areas shall be prepared on standard forms provided, whenever asked for by the Asst. Chief Engineer and forwarded to him at the earliest possible date.

In preparing lists of Irrigable and Non-Irrigable land in any district, Engineers will be guided by the following rules:—

1. The unit for determination of irrigable area will be the Quarter Section.
2. The irrigable area on each quarter section will be the total area which lies at a lower elevation than the point where the water is delivered to such quarter section, without any deduction for lakes or swamps.
3. The irrigable area for any parcel less than one-quarter section will include everything in the said parcel which is below the point of delivery to the quarter of which it forms part.
4. When right of way must be taken, but cannot be described from existing information, the parcel affected thereby will be marked as "Right of way to be taken, area to be ascertained later." Only in case of changes subsequent to the close of field work will such marking be accepted.
5. Areas Irrigable only at greater cost than \$5 per acre will be marked "Reserved for future construction."
6. Delivery will be made only at the highest attainable point on the boundary of each parcel, and at but one point.

(C) General.

Camp
Equipment

13. Tents, utensils and transport will be furnished by the Company. Engineers are responsible for their proper care and return in good condition with due allowance for reasonable wear and tear.

Personal
Equipment

14. All persons employed must furnish their own bedding and personal necessities. Engineers must furnish their own transits, levels and draughting instruments, and levelers their own levels. Persons using Company's instruments will be held responsible for their proper care, and in the case of levels, must pay \$3.00 per month rental for the use of the same.

Serious
Accident

15. In case of serious accident to anyone, necessitating hospital treatment, the Engineer must immediately notify the Strathmore office by telephone or messenger, giving full particulars as to circumstances of accident and character of injury. The injured person must be conveyed with all possible care to the nearest point on the railway at which there is an operator, and if necessary must be accompanied by some person until turned over to medical care.

All parties are notified that accident is a matter of personal responsibility and that the Company is in no way liable for the results, and that all persons accepting employment waive the right of recovery as a condition precedent thereto.

Serious
Illness

16. Cases of serious illness requiring medical treatment are to be handled in the same manner as accidents to the person.

Leave of
Absence

17. Leave of absence will only be granted (except for serious illness) by the Asst. Chief Engineer. Transportation over the Company's railway lines will not be granted under any circumstances, except for serious illness or accident necessitating hospital treatment, or in the case of transacting Departmental business.

Notice of
Resignation
or Dismissal

18. All employees are required to give two weeks notice of resignation; or otherwise they will forfeit pay for the same period. The same notice will be given them in case of dismissal for any cause other than flagrant breach of discipline, or the unavoidable general closing down

of the work. No time checks will be issued to employees resigning without good cause, whether notice of such resignation has been given or not.

Intoxicants
not to be
brought
into camp

19. No intoxicating liquors are to be brought into or kept in camp. Any infraction of this rule will be considered sufficient cause for dismissal without notice, as will the habitual use of such liquors in any place. Engineers must see that this rule is enforced.

Sanitary
condition
of camp

20. Engineers will be held personally responsible for the sanitary condition and cleanliness of the camps under their charge. Refuse must not be deposited in heaps, but must be placed in holes dug to receive it and covered over at short intervals of time. Wood chips and shavings are to be periodically burnt; stake-wood, firewood, lumber, etc., must be kept neatly piled; and the whole camp must at all times present a tidy and neat appearance. Personal uncleanness or unsanitary habits will constitute cause for immediate discharge without notice.

Prairie fires
and Fire
Protection

21. All employees are reminded of the "Act respecting Prairie Fires" and are warned that the Company will facilitate prosecutions in case of violation thereof.

All inflammable material must be kept well away from fires and to windward, in the direction of prevailing winds (north-west).

Employees living under canvas must extinguish fires in camp stoves before leaving them.

Engineers will arrange to plough a fireguard around each camp at the earliest opportunity, and will be responsible that such fireguard is at all times kept in good condition.

II.

SURVEYS AND CONSTRUCTION

(D) Surveys, Location and Design.

Land
Surveys

22. Attention is directed to the following extract from the Dominion Lands Act:—

127. "When, in the survey of legal subdivisions, it is necessary for a Dominion Land Surveyor to establish the division line between two sections, he shall effect this by connecting, by a straight line, the opposite original section corners, if they exist, and if not, by similarly connecting the points established in renewal thereof, in accordance with the next preceding clause, giving, in either case, the quarter sections involved an equal breadth.

2. In laying out a half section or a quarter section he shall connect the opposite quarter section posts by straight lines.

3. In laying out other and minor legal subdivisions he shall give to every such subdivision its proportionate share of frontage and interior breadth, and connect the resulting terminal points by a straight line.

4. The lines or limits so drawn on the ground in the manner above prescribed shall, in the respective cases, be the true lines or limits of such section, half section or other legal subdivision, whether the same correspond or do not correspond with the area expressed in the respective patents for such lands. 46 V., c. 17, s. III."

The following should also be noted:

The quarter section angle on a blind section line is defined by a point midway between the east and west limits of the section.

In quartering a section, lines are drawn joining the quarter section posts or mounds.

It is advisable to have bearings of all traverse lines within any section computed from some one boundary of the section, assuming it as running true to one or other of the cardinal points, and to have the bearings indicate which boundary is so taken.

It is also necessary to measure so many of the boundaries and angles as will enable the section and quarter section lines to be correctly plotted.

**Preliminary
Survey**

23. If reliable contour maps are available, they will answer all purposes of preliminary surveys. When they are not available, preliminary surveys will be necessary in order to determine the extent of the irrigable land and its distribution throughout the district. As a rule these surveys should be carried out as follows, in order to obtain the best results: 1st. A hasty location of a falling contour on an assumed grade whenever any large non-irrigable area is to be cut out. 2nd. Profiles over all the land lines where the lay of the land requires such. 3rd. Traverses, with or without profiles, of the principle watersheds and drainage channels.

Most of the above can be done with sufficient accuracy by stadia methods, and with a much more satisfactory rate of progress. Having put the information from the above surveys on paper, the Engineer should be able to work out the general scheme of distribution for the district, and to design the district canals and locate the same forthwith. The distributing ditches should require very little in the way of further preliminary work. The profiles of the land lines will show the point of delivery to each parcel, and these ditches are best located up grade from that point to the point of supply. In making the preliminary surveys, it will be advantageous to mark the chainage and direction of the land lines at very frequent intervals on firmly set stakes. Bench marks should be numerous, and should be set where they will do the most good; that is near canal or ditch locations, also at all land mounds or pits. All intersecting lines of levels should be tied together, and B.M's must be thoroughly checked before they are accepted as correct.

**Location
Surveys**

24. In location surveys it is best to let the level precede the transit: in fact, except where

right of way will be required, there is no need of a transit. The Engineer should locate a falling contour by rod and chain. For canals or ditches less than four feet bed, this contour, with slight modifications, is the final location. For larger ditches or canals, after locating a contour for say 1200 feet as a trial line, the contour should be straightened or "averaged" by a series of tangents and suitable curves put in at the apices. The lengths of these tangents and the maximum offset from the contour, are dependent on the size of the proposed canal and the transverse slope of the country, and are a matter of judgment for each case, and no general rules can be laid down to fit all cases. For small canals in steep broken country they are necessarily very short; whereas, in smooth, comparatively level country they may be very much longer. The above, of course, applies only to contour locations, where the grade of the canal more or less definitely fixes its location. On watershed locations, or on drop lines, the best procedure is to run bold lines from point to point as straight as possible, and then make such diversions from these lines as are shown to be necessary, or advisable, by the profile. Ties to land corners when not required for right-of-way purposes may be made by random lines, or stadia shots, not necessarily on the land lines. When they are required for right-of-way purposes, the land lines must be run out from mound to mound, and the intersection with the traverse established and the angles read. When time is available, a closed survey should be made of each quarter section affected.

BENCH MARKS on location surveys should be closely spaced, not over 1200 feet apart. A. B. M. should be set at every land line crossed, and at the probable site of every structure or group of structures. **LOCATION BENCH MARKS** should be of as permanent a character as possible.

INTERSECTIONS ON TRAVERSES should be well referenced for easy replacement, either by three lines intersecting over the point, or by two lines and two distances.

25. Where possible without sacrifice of land or economy in construction, District Canal systems will follow the boundary lines of the sys-

Locations
on Land
Lines

tem of land survey.

All Canals or Ditches located on land lines must be at least 12 feet clear thereof, and must not be on the road allowance. When they follow the general direction of a road allowance they will be located on the side which requires the fewest crossings.

Alignment

26. Canals should be as nearly straight as possible, consistent with economy in quantities, overhaul and structures. **FOR BED WIDTHS LESS THAN FOUR FEET** the location is best on a grade contour, with the lower slope stake in cut equal to or a little less than the depth of water; **FOR CANALS 4 FT. BED AND OVER**, the location is usually better when made by tangent and curves. Curvature should not be too sharp; from ten to fifteen times the depth of water is a suitable radius. The length of the curve itself should not be more than 200 feet, except for very large angles on large canals.

Profiles

27. The ideal profile would be a straight line parallel to the grade line at such a distance above it as would balance quantities. It is of course impracticable to secure anything like this; but it should be held in view as desirable. When crossing ravines or coulees, large canals should cross at or near grade; while smaller ones, below six feet bed, should cross in cut about equal to one-half the depth of water. Crossing of road allowances, where a bridge will be required, should be as nearly at right angles as possible; and canals at these points should be in slightly excess cutting to provide material for the approaches.

Duty of Water

28. The legal duty of water, or the area to be irrigated by a continuous flow of one cubic foot per second, is one hundred and fifty acres; smaller areas being allotted a proportionate quantity. To ensure the supply of water, required by law, the distributing ditches must be so designed as to give each parcel of land its proper quantity at the point of delivery, after providing for seepage, evaporation or other loss in transit. To accomplish this the smaller ditches will be constructed on a basis of carrying more water than is required to supply farms at the lower end, and our practice is that no distributing ditch should be of less size than two

and one-half feet wide by one foot deep.

29. The maximum velocity of water permitted is three feet per second; it cannot, however, be reached, as a rule, on contour lines, though it may on drop lines. It does not pay to adopt a steeper grade on contour ditches than 0.10 %, unless there is nothing to be gained by keeping up grade.

In general in designing District canal systems, engineers should aim at keeping water moving at a practically uniform velocity. Every time the velocity is checked it means the deposition of silt, which necessitates cleaning out; and, on the other hand, each increase in velocity means erosion, which is deposited at the next check.

On small ditches, 3-ft. bed and under, the maximum grade permitted will be 1 %, in the firmest soil. In loose sandy soil the maximum grade will be 0.5 %. Discharge diagrams furnished must be used in designing distributary ditches.

Where double fills occur on steep drop lines and the banks are spread apart to obtain material, the grade of the ditch may be increased for half mile **ABOVE** the fills to a rate which will give a velocity of 4 feet per second. Drops to correct this grade may be built subsequently if the need of such developments.

30. In designing the cross sections for any canal, **KUTTER'S FORMULA FOR DISCHARGE** is to be used, the factor N being taken at 0.025.

As the velocity of water in any canal depends on the cross section and grade; if the latter is fixed, the velocity can be varied within considerable limits by alteration of the cross section. The section giving maximum velocity, and consequently maximum discharge, for a given area and grade would be the semi-circle, and the nearer the cross-section approaches a semi-circle the higher the velocity. As long as the rate of grade is such that the highest attainable velocity is less than three feet per second, there is a large possible saving in excavation by a judicious choice of cross sections. Where part of a canal is in fill, carrying water, the slopes should not be less than $1\frac{1}{2}$ horizontal to 1 vertical. For this slope the cross section which gives the maximum area for minimum

wetted perimeter (and consequently a maximum Hydraulic radius) is when the bed width and depth are in the ratio of about 6 to 10. The variation in \sqrt{T} is very slight however until the ratio exceeds about 25 to 10, after which the value of \sqrt{T} decreases very rapidly for any given area. Between the limits of 6 to 10 and 25 to 10 any ratio is admissible without any noticeable sacrifice of efficiency.

On drop lines, by using a ratio higher than above, it may be possible to keep the velocity inside the maximum on even moderately steep grades, and thus dispense with a number of costly drops. In solid rock the most economical section is a semi-hexagon for all grades.

All calculations for Main, Secondary or large District Canals will be made upon the printed forms provided, and must be signed by the Engineer making the calculations, and checked by the Chief Division Engineer, who will initial same to indicate check.

Method of
Balancing
Quantities

31. Probably the best way of locating a line on which cut and fill will balance, is to run out a falling contour for the point on the cross section at which the cut will balance the fill, after allowing for shrinkage, for any degree of transverse slope whatever. Such point may be found as shown on the attached blue print of Plan No. 673A.

After cross sections are taken and quantities calculated, the mass curve is plotted, and overhaul, borrow, and waste noted on the profile. Points where these are excessive, or where the quantities are unreasonably high, must then be corrected in the field where possible.

Right-of-
Way
to be taken

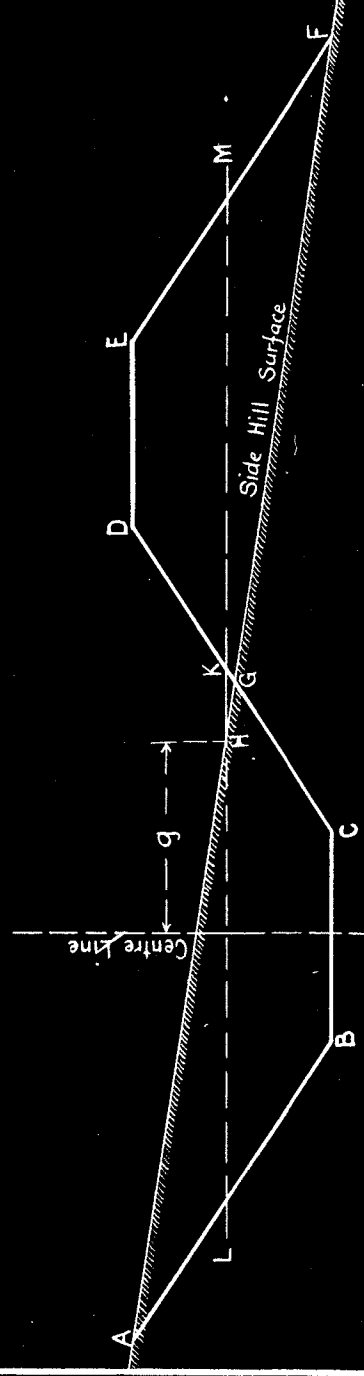
32. Right-of-way is taken for all canals having a bed width of 5 feet or over, and for all canals and ditches of any size through lands which are not the property of the Company. When surveys are required for right-of-way purposes, they will be made according to the "Dominion Lands Act" and the "Land Titles Act." These Acts require a description by metes and bounds, and all surveys for this purpose must be made with this end in view.

Reservations for right-of-way are as hereunder :—

CANADIAN PACIFIC RAILWAY CO. IRRIGATION DEPARTMENT

Diagram to illustrate
method of balancing quantities
on Contour Ditches.

Calgary, March 1908.



Proof.

Assume that A.B. (upper slope of ditch) is parallel to E.F. (outer slope of bank). Determine depth of level cutting for which the cut will just make the fill, represented in diagram by line L-M.

Through H. (the centre of L-M.) pass any line A-F. representing the side hill surface.

Then by construction we have

Area L.B.C.K. = Area K.M.E.D.

Also since A.B. and E.F. are assumed to be parallel Triangle A.L.H. = Triangle H.F.M.

Now for the surface A-F. the cut is represented by area A.B.C.G. and the fill by area G.F.E.D.

But area A.B.C.G. = area L.B.C.K. + area A.L.H. = area H.G.K.

And area G.F.E.D. = area K.M.E.D. + area H.F.M. = area H.G.K.

Therefore area A.B.C.G. = area G.F.E.D.

Method of procedure in the field.

Determine distance "g" from centre line of ditch to "H" the midpoint of level cutting for required cross-section of ditch and bank.

Locate centre line by running a falling contour for a centre cut equal to the depth of level cutting represented by L-M. and move each stake up the hill the distance "g".

Straighten in the stakes so as to give a practicable alignment.

NOTE. The method may be modified to provide for shrinkage, and it will be of some service even where the upper slope of ditch and the outer slope of bank are not the same.— See Table I of Standard Cross-sections for contour locations. (Plan. No. 673.)

Allowance for shrinkage is to be 15 %.

For Main Canals

150 feet on lower side of center line.

100 feet on upper side of center line.

Extra width where required on account of high fills, borrow, waste or flooded areas, the latter to be included within a series of tangents.

For Secondary Canals

125 feet on lower side.

75 feet on upper side.

Extra widths as referred to above.

For Main Distributaries (5 feet bed and larger)

Allow about 10 feet from upper cut stakes and allow about 20 feet from lower bank stakes, making the total width of right-of-way a multiple of 5 feet, and keeping the width uniform for ditches of any one size. The same allowance to be made for high fills, borrow, waste or flooded areas as outlined above.

For Small Ditches

No right-of-way will be reserved for ditches under 5 feet bed width except through private lands; in which case a 40-foot strip should be sufficient, with about 15 feet on the upper side and 25 feet on the lower side of centre line, making the strip follow the general alignment of the ditch as nearly as possible by a series of tangents.

Method of
Numbering
Canals,
Ditches, and
Structures

33. DISTRICT CANALS, which include all canals heading in secondary canals and all others over 5-foot bed, will be given a distinguishing letter and referred to as District Canals "A," "B," "C," etc., in each Irrigation District, and will keep this letter throughout their length. When the canal forks into two or more branches, the branch to the left, going down stream, will retain the original letter, and the other branches will be given new letters in order. Letters must be clearly shown on District maps, and the length of canal to which each applies must be distinctly indicated.

DISTRIBUTING DITCHES heading in District canals will be numbered in the order in which they are taken off from District canals, the number being prefixed by the distinguishing letter of the District canal in which they head, as "A.1," "A.2," etc. When a distributing ditch forks into two or more branches, the branch leading to the left, going down stream, is to retain the original number, and the ones to the right will receive additional numbers, in the order in which the water reaches them, as "A.1-1," "A.1-2," "A.1-3." Should more than one branch leave a distributing ditch at any point, they will be numbered in order from the left. The same principle will be followed with all subsequent branches, i.e., the ditch leading to the left will retain the number of the ditch in which it heads, and the forks to the right will get additional numbers in order. Short ditches of 100 feet or so, **WITHOUT ANY STRUCTURES**, which only serve single sale parcels, are to be treated as outlets and neglected in numbering.

NATURAL WATER COURSES used to carry water for irrigation will be treated as either District Canals or Distributing Ditches, and numbered as such. Parts of such courses not so used will not be considered as part of the system.

STRUCTURES will be numbered in order, independently of their kind, and the number of the structure will be followed by the number of the ditch or canal on which it occurs, a new series being started for each new number, but continuous on the old one.

GATES are to be considered as structures on the canal which feeds them, and not on the one which they feed.

It is to be understood that the relative size or importance of any canal or ditch has nothing whatever to do with its number, the system being based on the principle of **KEEPING TO THE LEFT** when a ditch forks.

SPILLWAY CHANNELS from secondary canals or the larger district canals will be **NAMED**, if not used as irrigation channels. When they are so used they will be numbered as above.

It is recognised that the rules as outlined above cannot be immediately followed during location; but as soon as the work of location is

CANADIAN PACIFIC RAILWAY CO IRRIGATION DEPARTMENT Diagram to illustrate method of numbering District Canals and Distributing Ditches

Calgary, March 1908.



sufficiently far advanced to admit of it, this method **MUST** be applied in designating the various units of the distributing system in any district.

The attached blue print of Plan No. 246 is made with a view of illustrating the system herein referred to.

Maps,
Profiles, and
Records

34. All maps, plans, profiles, or records of any description are the property of the Company, and must not be given to any person not connected with the Department, without direct permission of the Asst. Chief Engineer; and no information whatever regarding the work is to be given out without his authority.

Strict compliance with instructions, and in accordance with samples given, is expected, concerning the preparation of maps, profiles, records and estimates.

So far as practicable, all maps, profiles, estimates and general records must be completed while the surveys are in progress, thus avoiding unnecessary accumulations at the close of the season.

RIGHT-OF-WAY PLANS will be on a scale of 250 feet to an inch, and on sheets provided. They must give the necessary information to permit of a proper description being prepared of the land to be taken, and should be plotted by latitudes and departures.

ALL LATITUDE AND DEPARTURE CALCULATIONS will be made on the forms provided, and must be signed by the Engineer making same, and checked by some other member of the staff, who will initial same to indicate check.

FIELD PLANS will be prepared to a scale of 1,000 feet to an inch, showing all canal or ditch locations, traverse lines, streams, drainage channels, roads or other information obtained. These plans must be kept up-to-date in camp.

PROFILES of all canal or ditch locations will be prepared on profile paper, to a horizontal scale of 400 feet to an inch, and a vertical scale of 20 feet to an inch. They must show ground elevation, grade, and water-line, and location and character of all structures, and also all bench marks, where possible, and must be kept up-to-date in camp.

All maps and profiles must contain the name of Engineer or Draftsman and date.

All information obtained must be recorded in **FIELD BOOKS SUPPLIED FOR THE PURPOSE**. They should indicate each day's work, giving date and weather conditions. The fly-leaf of each book must show in ink the name of each branch or section of the work which the notes cover, and also the name of Engineer or Instrument-man. All notes of **ABANDONED LINES** should be marked as such, and **MUST NOT BE ERASED**. Notes should be so kept that they may be understood by **ANYONE**. The field books must be indexed and turned in to the general office on completion of the work.

ALL LEVEL NOTES must be checked at the end of each day's work, and each page of levels must be proved in the field.

(E) Canal Construction

Excavations
generally

35. Cuttings and embankments must be in strict accordance with the specifications, and no variation will be allowed without written authority for each case. Waste material must be put outside the banks and used to widen them uniformly, or else to strengthen the lower two-thirds of the embankment in the nearest coulee crossed by the ditch; if it can be put there without incurring excessive overhaul. Borrowing, when necessary, is to be done by—(1) deepening the canal; or, (2) widening it if ("I") is not possible; or, (3) both if required. If neither are practicable, borrow pits may be made, well away from the canal, on the high side. They must be arranged to drain into the canal. Borrow for double fills may be made by spreading the banks far enough apart to get the material between them, but the material for fills and levees of all descriptions should be overhauled from canal excavations whenever it is possible to so locate the line. Side borrow for levees and double fills will not be allowed outside the banks. The Standard Cross Sections, as shown on attached blue prints of Plans 673 and 673 B, must be adhered to.

Embank-
ments

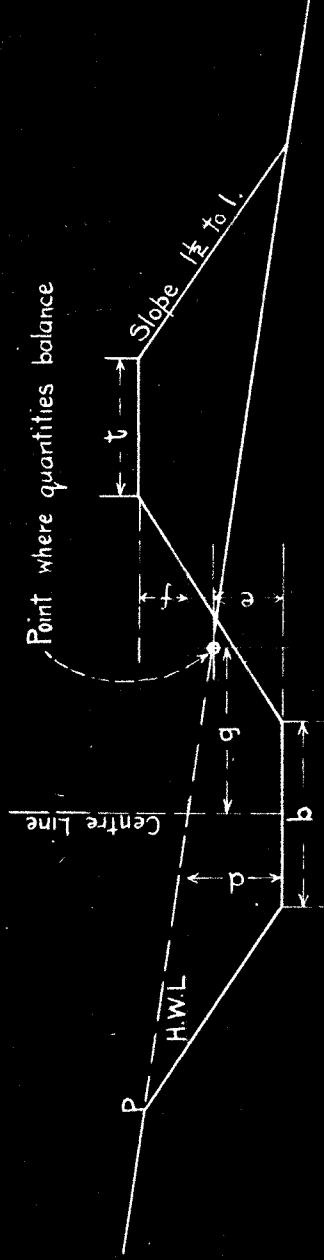
36. The outer slope of embankments should never be steeper than $1\frac{1}{2}$ to 1 if the canal carries water against them. Where they are used as part of the canal prism the minimum depth of cutting, at the lower slope stake, is two-thirds the depth of water. This requirement, while not absolutely insisted on in every case, should

CANADIAN PACIFIC RAILWAY C9 IRRIGATION DEPARTMENT

Standard Cross Sections

Table I. for Contour Locations.

Calgary, March. 1908.



b	d	f	t	g	e	Side Slopes	Q = AC√rs		
							√r	A	C.
2.5'	1.0					1 to 1.	0.81	3.50'	48.4
3.0	1.0					"	0.83	4.00	49.5
"	1.1					"	0.85	4.51	50.2
"	1.2					"	0.89	5.04	51.6
"	1.3					"	0.92	5.58	52.5
"	1.4					"	0.94	6.16	53.1
"	1.5					"	0.97	6.75	54.1
3.5	1.5					"	0.97	7.25	54.1
"	1.6	1.0	3.0	3.3	1.5	"	1.01	8.15	55.3
"	1.7	"	"	3.3	"	"	1.03	8.83	55.9
"	1.8	"	"	3.3	"	"	1.06	9.54	56.7
"	1.9	"	"	3.3	"	"	1.08	10.25	57.3
"	2.0	"	"	3.3	"	"	1.10	11.00	57.9
4.0	2.0	"	"	3.6	"	1 1/2 to 1.	1.12	14.00	58.4
"	2.1	"	"	3.6	"	"	1.14	14.91	58.9
"	2.2	"	"	3.7	"	"	1.16	16.06	59.4
"	2.3	"	"	3.7	"	"	1.19	17.25	60.2
"	2.4	"	"	3.7	1.6	"	1.20	18.24	60.4
"	2.5	"	"	3.8	1.7	"	1.22	19.25	60.6
"	2.6	"	"	4.0	1.7	"	1.24	20.54	61.4
"	2.8	"	"	4.2	1.9	"	1.28	22.96	62.5
"	3.0	"	"	4.3	2.0	"	1.31	25.50	63.0
4.5	3.0	"	4.0	5.0	2.0	"	1.33	27.00	63.5
"	3.2	"	4.0	5.1	2.1	"	1.36	29.76	64.1
5.0	3.2	"	4.5	5.4	2.1	"	1.38	31.36	64.6
"	3.4	"	4.5	5.4	2.3	"	1.41	34.34	65.2
5.5	3.4	1.1	5.0	5.7	2.3	"	1.43	36.04	65.6
"	3.6	1.1	5.0	5.9	2.4	"	1.46	39.24	66.2
6.0	3.6	1.1	5.5	6.2	2.4	"	1.47	41.04	66.4
"	3.8	1.1	5.5	6.3	2.5	"	1.51	44.46	67.2
6.5	3.8	1.2	5.5	6.3	2.5	"	1.52	46.36	67.4
"	4.0	1.3	5.5	6.7	2.7	"	1.55	50.00	67.9
7.0	4.0	1.3	6.0	6.9	2.7	"	1.56	52.00	68.1
"	4.2	1.3	"	7.0	2.8	"	1.61	56.80	69.1
7.5	4.2	1.4	"	7.2	2.8	"	1.62	58.90	69.2
"	4.4	1.4	"	7.3	2.9	"	1.63	62.00	69.4
8.0	4.4	1.5	"	7.5	2.9	"	1.64	64.20	69.6
"	4.6	1.6	"	7.7	3.1	"	1.67	68.20	70.1
9.0	4.6	1.7	"	7.8	3.1	"	1.69	72.70	70.4
"	4.8	1.8	"	8.1	3.2	"	1.73	78.70	71.1
10.0	4.8	1.9	"	8.3	3.2	"	1.75	83.50	71.5
"	5.0	2.0	"	8.6	3.3	"	1.77	87.50	71.8

As a general rule no dependence is to be placed on banks as part of canal prism unless the grade is 10' below the underside of the sod, or say 1.5' cut as an average.

The factor "C" is calculated for a grade of .06%. It varies to a considerable extent as the grade varies, and should be recalculated by Kutter's formula as a final check.

The cut at the point P. should not be less, on the average than the depth of water "d." and the dimensions in the table are subject to that condition.

CANADIAN PACIFIC RAILWAY CO.
IRRIGATION DEPARTMENT

Cross Sections for Drop Locations.
Formulae and Tables for designing,
with Explanations. (3 sheets.)

Calgary, April, 1908.

Sheet 2. Table I.

Value of Kütter's Coefficient. ($n = 0.025$; s . (ratio of grade) $= 0.0006$)

Note: Variation is very slight for steeper grades.

[illegible]

CANADIAN PACIFIC RAILWAY CO.
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Cross Sections for Drop Locations. Formulae and Tables for designing, with Explanations. (3 sheets)

Calgary, April. 1908.

Sheet 3. Tables II and III.

Table II

Values of B and K when h (side slopes) = 1.5 to 1.

Note:- For any other side slopes $B'' = \frac{\sqrt{m+h}}{m + 2\sqrt{1+h^2}}$ and $K'' = \sqrt{m+h}$

m	B	K	m	B	K	m	B	K	m	B	K	m	B	K	m	B	K
0.1	.342	1.265	1.6	.338	1.761	3.1	.321	2.143	4.6	.301	2.469	6.1	.285	2.756			
0.2	.343	1.303	1.7	.337	1.789	3.2	.319	2.168	4.7	.300	2.489	6.2	.284	2.774			
0.3	.344	1.342	1.8	.337	1.815	3.3	.318	2.190	4.8	.299	2.509	6.3	.282	2.792			
0.4	.345	1.378	1.9	.336	1.844	3.4	.317	2.212	4.9	.298	2.529	6.4	.281	2.810			
0.5	.345	1.414	2.0	.334	1.871	3.5	.316	2.234	5.0	.297	2.549	6.5	.280	2.828			
0.6	.345	1.450	2.1	.333	1.898	3.6	.314	2.259	5.1	.296	2.568	6.6	.279	2.845			
0.7	.345	1.483	2.2	.332	1.923	3.7	.313	2.280	5.2	.295	2.587	6.7	.278	2.862			
0.8	.345	1.516	2.3	.331	1.950	3.8	.311	2.301	5.3	.293	2.606	6.8	.277	2.879			
0.9	.344	1.549	2.4	.329	1.975	3.9	.310	2.323	5.4	.292	2.626	6.9	.276	2.896			
1.0	.344	1.581	2.5	.328	2.000	4.0	.309	2.343	5.5	.291	2.645	7.0	.275	2.913			
1.1	.343	1.612	2.6	.326	2.025	4.1	.308	2.368	5.6	.290	2.664						
1.2	.342	1.643	2.7	.325	2.049	4.2	.306	2.388	5.7	.289	2.682						
1.3	.342	1.672	2.8	.324	2.073	4.3	.305	2.409	5.8	.288	2.701						
1.4	.341	1.702	2.9	.323	2.098	4.4	.303	2.429	5.9	.287	2.720						
1.5	.340	1.732	3.0	.322	2.122	4.5	.302	2.449	6.0	.286	2.738						

Table III

Allowable Maximum values of "m":

Area	m.	Area	m.	Area	m.	Area	m.	Area	m.	Area	m.	Area	m.	Area	m.	Area	m.
3.5	2.5	6.0	4.1	21.0	4.6	65.0	5.1	190.0	5.6	480.0	6.1						
4.0	2.8	8.0	4.2	27.0	4.7	80.0	5.2	230.0	5.7	590.0	6.2						
4.5	3.2	10.0	4.3	35.0	4.8	100.0	5.3	280.0	5.8	700.0	6.3						
5.0	3.5	13.0	4.4	43.0	4.9	125.0	5.4	330.0	5.9	820.0	6.4						
5.5	3.8	17.0	4.5	53.0	5.0	155.0	5.5	400.0	6.0	960.0	6.5						

be followed as far as possible when locating Main or Secondary Canals and where no other consideration governs. Embankments should be strengthened in all cases where crossing ravines or coulees, and on the outside of all curves if waste material is available. In estimating cross section areas in embankments or dams for purposes of balancing quantities, or calculating overhaul, an allowance of 15 % should be added for shrinkage and settlement.

Double Fills
and Levees

37. Embankments carrying water, such as double fills, etc., must be at least three feet wide on top, twelve inches above water level at least, and must have at least $1\frac{1}{2}$ to 1 slopes. The original surface must be stripped or bonded.

Levees will be staked out for a height of six inches above the water level in the proposed ditch. They will have width at water level of 9 feet plus the water level width of the ditch. They will be built solid to their full height and the ditch subsequently excavated in them, the material being placed on each side evenly.

Before deciding on a levee or a double fill for a particular service, a comparative estimate must be made, and the cheaper method adopted. As a rule the levee is cheaper when the height exceeds the depth of water by a little less than half the bed width of the proposed ditch; the height in such cases being measured to the full supply level.

Small
Ditches

38. On drop lines, small ditches should be excavated to a uniform depth below the surface.

Side slopes will be 1 to 1, and they shall not be designed for a velocity of more than three feet per second. Where they are taken out of coulees, the upper hundred feet should be located in cutting at least six inches more than the depth of water they are designed to carry.

Dams on coulees should be at least 2 feet above water level in distributary, not less than 3 feet wide on top, and with $1\frac{1}{2}$ to 1 slopes at least.

The table of standard cross sections must be adhered to on all contour locations. (See attached blue print of Plan No. 673).

Stripping
and
Bonding

39. Stripping and bonding will be required when banks carry more than ten feet of water, or where the natural sod and soil are more than

ten inches deep, and in boggy or marshy ground. Where the height of fill is equal to, or greater than, the depth of water, the ground under the banks must be stripped or bonded out to a point where a 3 to 1 slope from the water level would intersect the ground. Where banks carrying water have to be built on steep ground, the stripped area under them must be plowed after stripping, and before the banks are built. Read carefully Clauses 5 and 6 of Specification for Canal Construction, and see that they are followed.

Overhaul
Specifica-
tion

40. The definition of overhaul, as given in the Specification for Canal Construction, Clause 12, forbids payment for movement unless such movement has a component parallel to the canal axis of more than 100 feet, except in the case of borrow pits.

The distance for which payment is made is to be measured on the canal axis.

The distance from the highest point on the cutting to the lowest point on the fill, on the same cross section, might be much more than 100 feet, but no payment for overhaul would be made thereon, as there is no component parallel to the canal axis.

In the case of borrow pits, not on the ordinary cross section, i.e., not connected with the canal except by a drain, it is specified that the distance is to be measured in a straight line between centers of gravity of cut and fill. Such overhaul will appear on the mass curve as borrow, and not overhaul, and must be shown by a separate notation to that effect.

Calculation
of
Overhaul

41. Overhaul is to be calculated by the method of mass curve in every case.

To compile the mass curve, the excess, whether positive or negative, of excavation over embankment at each station, is tabulated and summed algebraically for each station in succession. Any horizontal line on the profile paper is taken as zero, and the algebraic sum of the differences up to any station is plotted by a scale of cubic yards to an inch on the same vertical line as the same station on the profile. Positive quantities are plotted above the zero line, while negative quantities are plotted below. The points are joined up as in plotting profiles, and areas balanced by a horizontal line (not

necessarily the zero line) in exactly the same manner as cut and fill are balanced on a railway profile.

The length, in stations, of the intercept on the balancing line by the mass curve, multiplied by the **MEAN ORDINATE** to the mass curve from the balancing line, measured in cubic yards, gives the **TOTAL OVERHAUL** in yard-stations for the part of the work under consideration; from which must be deducted the **FREE HAUL**, which is the **MAXIMUM ORDINATE** in yards, multiplied by one station. The balance is the overhaul for which payment is to be made. This is to be noted in detail on the profile. Whenever the balancing line has to be broken and shifted, either up or down, to a new position in order to balance the areas, the vertical distance between the new and the old positions, is a measure, to the scale of yards, of the borrow when moved down, or the waste when moved up. Quantities of borrow or waste are to be shown in detail on the profile. When the average haul in stations exceeds the economical length, i.e., when it costs as much to haul as it does to borrow, the balancing line must be shifted or a re-location of the canal made to give a new mass curve.

(F) Timber Construction

Structures
generally

42. The number and size of structures should be cut down to a minimum. Where ravines or coulees are crossed by canals there is no need of any structure unless the catchment basin above the canal is large.

Flumes

43. Avoid flumes where possible. Unless a ravine is very deep, an escape in the bank is better; and where a canal crosses a summit a double fill or a levee is better and cheaper up to a height a little greater than the depth of water. Where they are unavoidable they should be as short as possible. On distributing ditches, flumes should never be used except where grade must be held up when crossing saddles, and a levee or fill would cost too much. The standard flume costs about \$2.00 per foot length up to heights of about 10 feet, and at this rate, unless a large additional acreage is obtainable by holding up grade, a flume would hardly pay

unless very short. Land that will cost much more than \$5.00 per acre for a distributing system is too expensive to serve at present. Refer all such cases to Headquarters for decision.

The above does not apply to inclined flumes which are to be used as a substitute for drops whenever they compare economically, or possibly even a little before that point is reached. As a means of overcoming great difference of elevation they are preferable to drops when they can be used. Frequently by care in locating canals a number of falls may be concentrated in a length short enough to permit of the substitution of an inclined flume with advantage.

Drops

44. Drops on Secondary or District Canals should be located in about half cutting above the structures. Where possible they should be concentrated, and height and number should be adjusted to one another for utmost economy. On all canals, drops should be avoided where possible by utilizing natural channels for carrying water, where it is evident these cannot be cultivated. On distributing ditches the standard drop is one foot.

Gates

45. **ALL GATES ON SECONDARY AND DISTRICT CANALS** should be in half cutting where practicable. As a general rule the sill elevation of distributary gates should be that of the bed of the canal feeding them. Cases will arise where a higher level is necessary to command additional land. In such cases the extra cost of the gates, which must be placed across the parent canal, should be balanced against the additional land commanded at \$5.00 per acre before a decision is arrived at. Refer such cases to Headquarters for decision.

DISTRICT HEADGATES should have a width in the clear equal to the bed width of the canal they serve, and must be built to the same grade elevation. As a rule both should leave the Secondary at grade, and District Canals should be located on that basis. See above.

BRANCH GATES IN DISTRICT CANALS will, as a rule, be designed on the same principle as District Headgates, for all canals 5-foot bed and over. For canals and ditches 4-foot bed and under they will be built in such a way that both branches may be stopped when necessary.

FARM SUPPLY GATES will be built to

standard plan. The walls must be of sufficient height to allow for the ultimate construction of the standard measuring weir.

ALL GATES are to be built to standard plans, and any variation or combination not standard, must be authorised by the Division Engineer before construction.

Measuring
Weirs

46. Provision must be made, when locating, for the ultimate construction of the standard measuring weir at each supply point. The effect of this weir will be to back up water above grade at the supply point, and it will be necessary in locating to keep this fact in mind, and locate in extra cutting, or, when possible, make provision for embanking the canal to take care of the extra depth. This extra depth will run out in a few hundred feet, the distance depending on the rate of grade. Weirs will not be constructed except by special instructions for each case, but provision for their ultimate construction must always be made.

Bridges

47. Bridges should not be built where it is possible economically to divert the road allowance to pass by the canal, or to make one bridge serve two or more roads. They are to be provided for at every road allowance crossed by the canal, which cannot be diverted. For the present, culverts on 2.5-foot and 3-foot ditches will be built only when the immediate necessity therefor is apparent. The approaches to bridges should be twenty feet wide with side slopes $1\frac{1}{2}$ to 1, and should not as a rule be steeper than 1 in 20; for culverts the approaches need not exceed 16 feet in width. Distributing ditches and canals should be in slightly excess cutting to avoid built-up approaches, and should cross roads at, or as near, right angles as possible. In certain extreme cases it may prove desirable to build skew bridges.

Questions
out of the
ordinary
run

48. Questions out of the ordinary run in connection with location or construction will be referred to Headquarters for decision.

In cases of emergency requiring immediate action, Engineers will use their own judgment. A report covering fully any such case must be made without delay to Strathmore Headquarters.

A. S. DAWSON,

ASST. CHIEF ENGINEER.

CALGARY, Alberta,

15th April, 1908.

Approved—

J. S. DENNIS,

SUPERINTENDENT OF IRRIGATION.

